An Integrated Modeling Approach to Inform Natural Resource Management in a Changing Climate

Introduction to BioEarth Project

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Nutrient Roundtable

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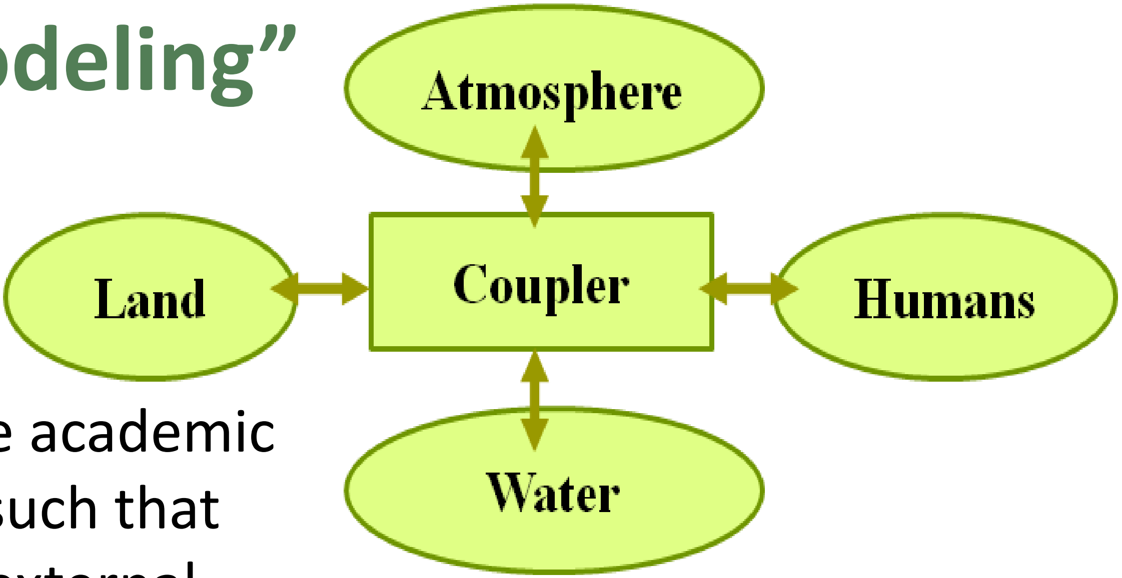
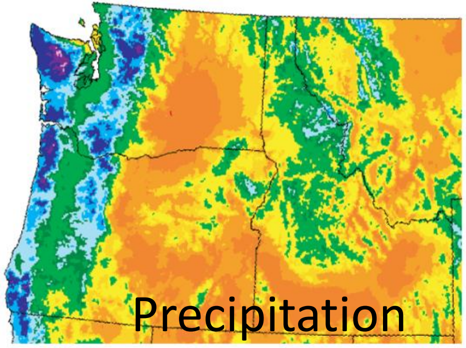
What does "Integrated Environmental Modeling" mean?



Definition:
"Models from two or more academic disciplines are integrated such that they behave like a unit to external stimuli." – Andy Soos, ENN

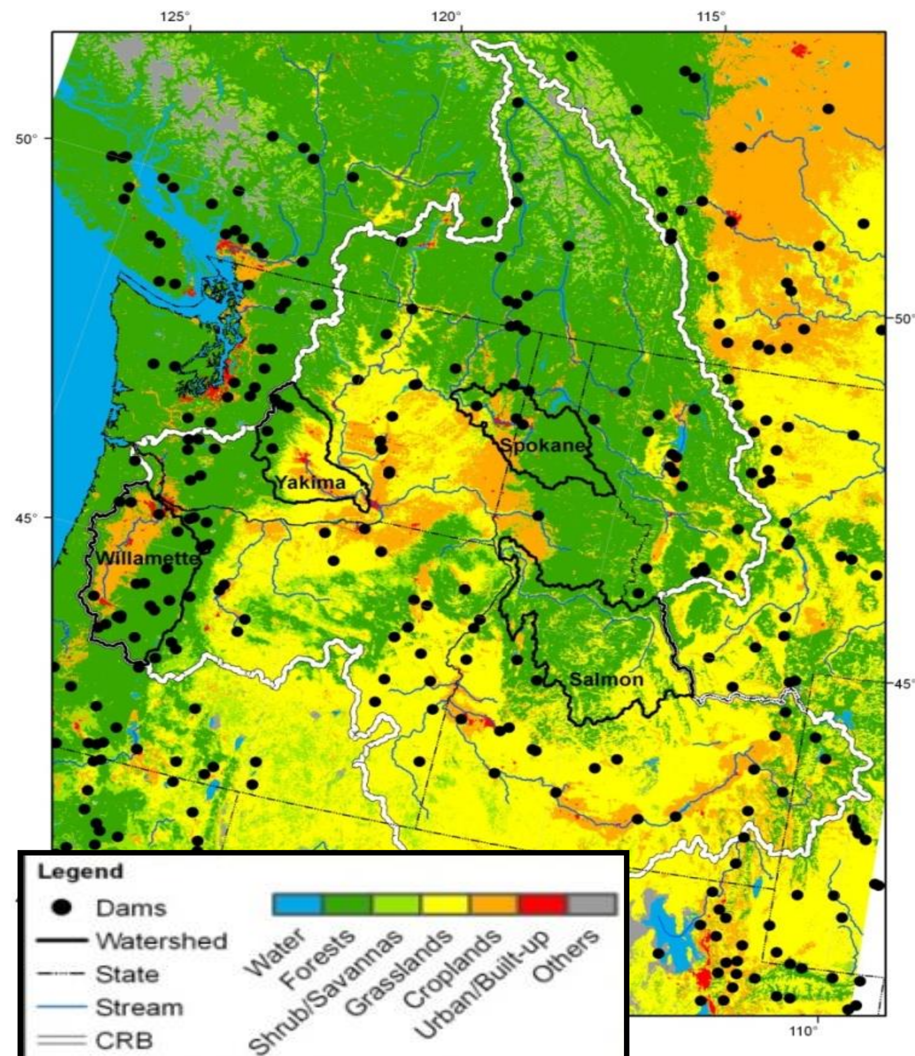
Advantages over Stand-Alone Models:

– Can explores 2-way effects & feedbacks
– Can reveal unintended consequences of proposed changes in policy or management practices by considering the Earth "*as a system*"



Regional Context: The Columbia River Basin (CRB) as a Natural and Agricultural Resource

- Projected temperature and precipitation changes anticipated to exacerbate water quantity and quality problems
- Multiple competing in- and out-of-stream water uses
- U.S.-Canadian water management; the 1961 Columbia River Treaty is currently under review
- Intensifying issues: fish and habitat, tribal considerations, increased need for renewable energy, etc.
- Need to incorporate regionally-specific processes/information



BioEarth's Overarching Goals

- Make projections about how climate change will impact coupled Carbon, Nitrogen and water dynamics in the region
- Improve understanding of the role resource management activities play in PNW earth systems
- Inform agricultural, rangeland and forest management decisions at multiple time-scales

What are the projected outcomes of resource management practices and policies?

Consider possible unintended consequences

Team of Collaborators- Diverse Expertise

Washington State University:

Bio. Sciences: Dave Evans, Sarah Anderson, Justin Poinsatte

Bio. Systems Eng.: Claudio Stöckle, Roger Nelson, Keyvan Malek

Center for Sustaining Agriculture and Natural Resources: Chad Kruger, Elizabeth Allen, Georgine Yorgey

Civil and Env. Eng.: Jennifer Adam, Mike Barber, Kirti Rajagopalan, Kiran Chinnayakanahalli, Mingliang Liu, Julian Reyes, Shifa Dinesh

Computer Sciences: Ananth Kalyanaraman, Tristan Mullis

Economics: Michael Brady, Jonathan Yoder, Bhagyam Chandrasekharan

Extension: Andy Perleberg

Lab for Atmospheric Research: Brian Lamb, Serena Chung, Joseph Vaughan, Fok-Yan Leung, Tsengel Nergui

School of the Environment: John Harrison, Cody Miller, Will Forney

University of Vermont: Jennie Stephens

Notre Dame: Alan Hamlet

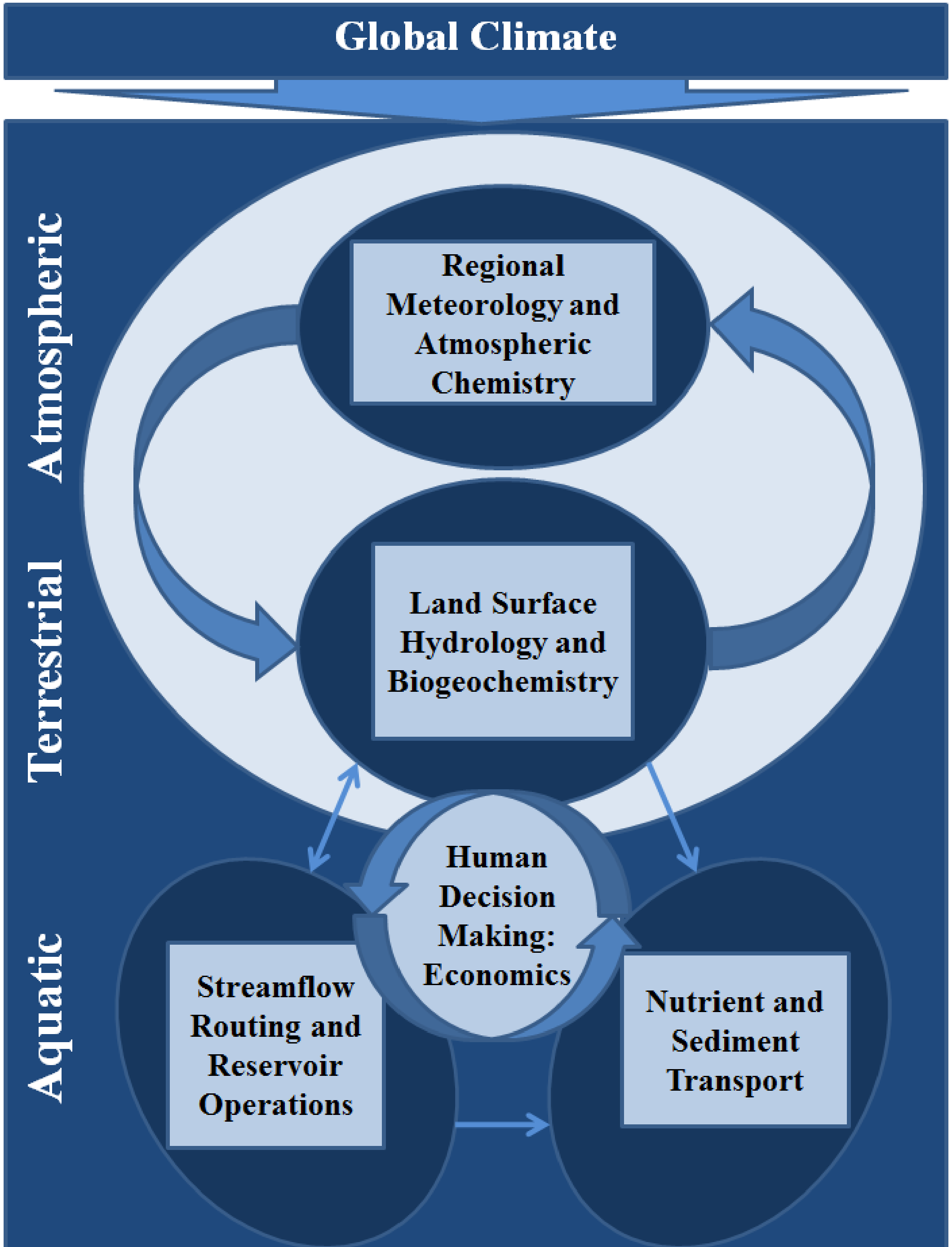
Oregon State University: Yong Chen

Pacific Northwest National Lab: Alex Guenther, Ruby Leung, Jin-ho Yoon

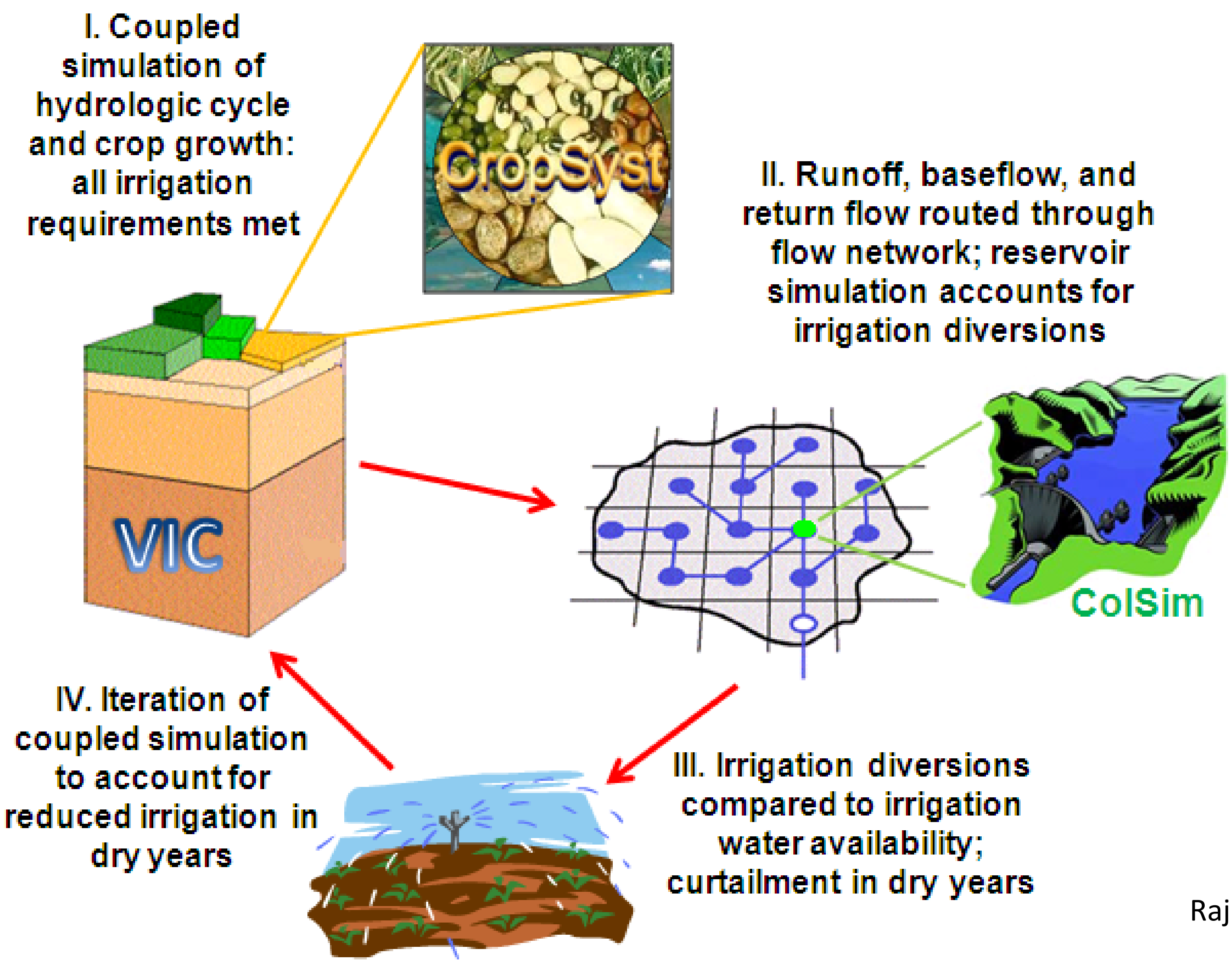
University of California, Santa Barbara: Christina Tague, Jun Zhu, Janet Choate

University of Washington: Bart Nijssen

BioEarth's Modular Framework: Models can be coupled to address specific questions



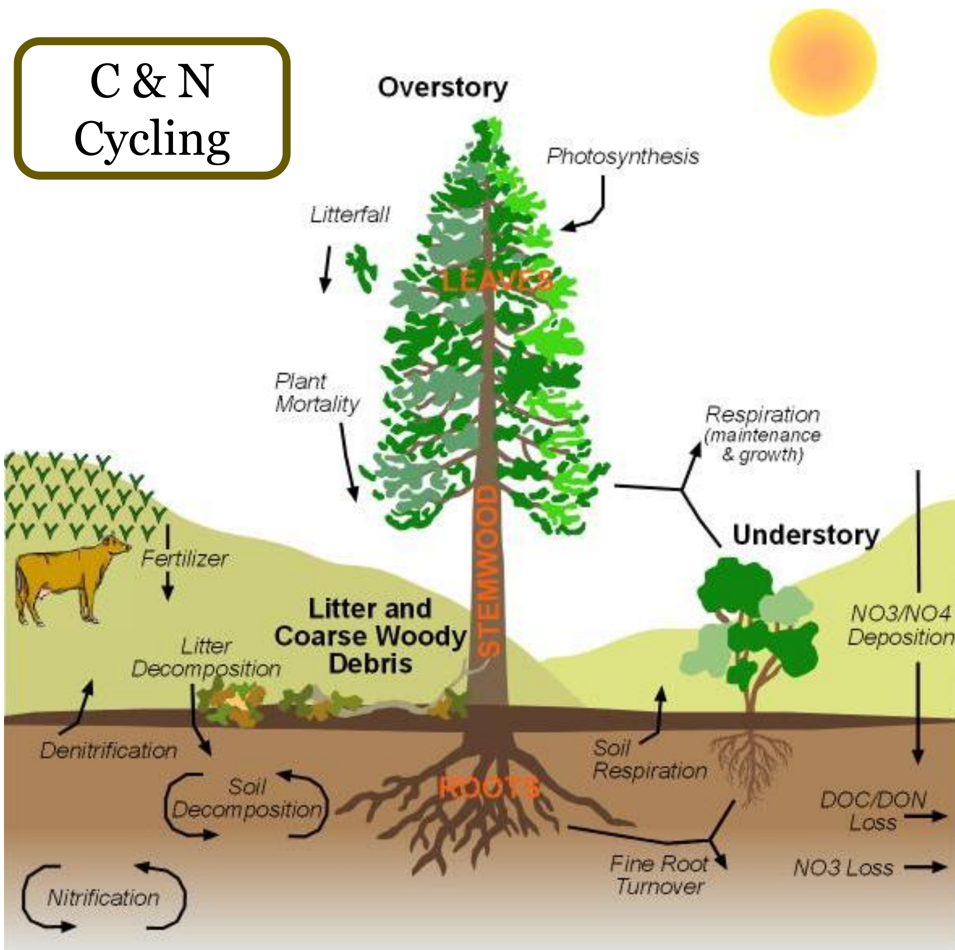
Integrated Hydrology, Cropping Systems, and Water Management



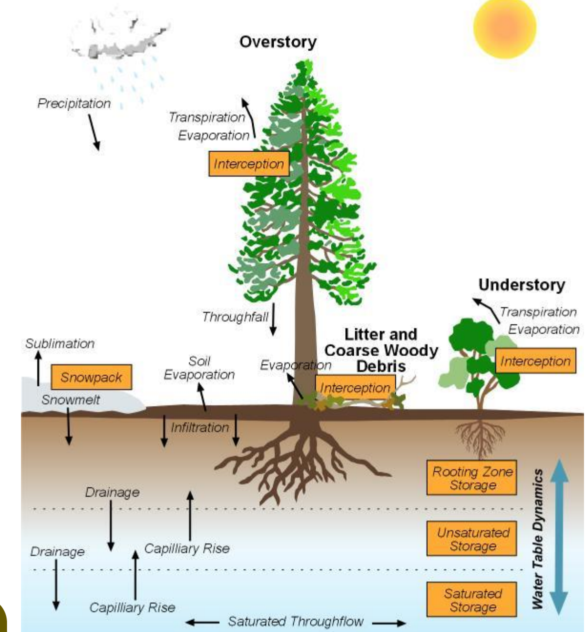
Stöckle et al. (2014)
Adam et al. (2014)
Rajagopalan et al. (in prep)

Regional Hydro-Ecologic Simulation System (RHESSys)

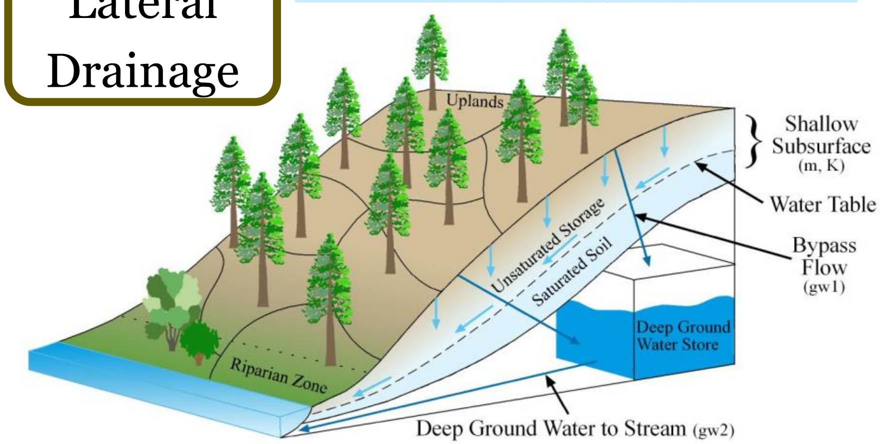
C & N Cycling



Vertical Drainage

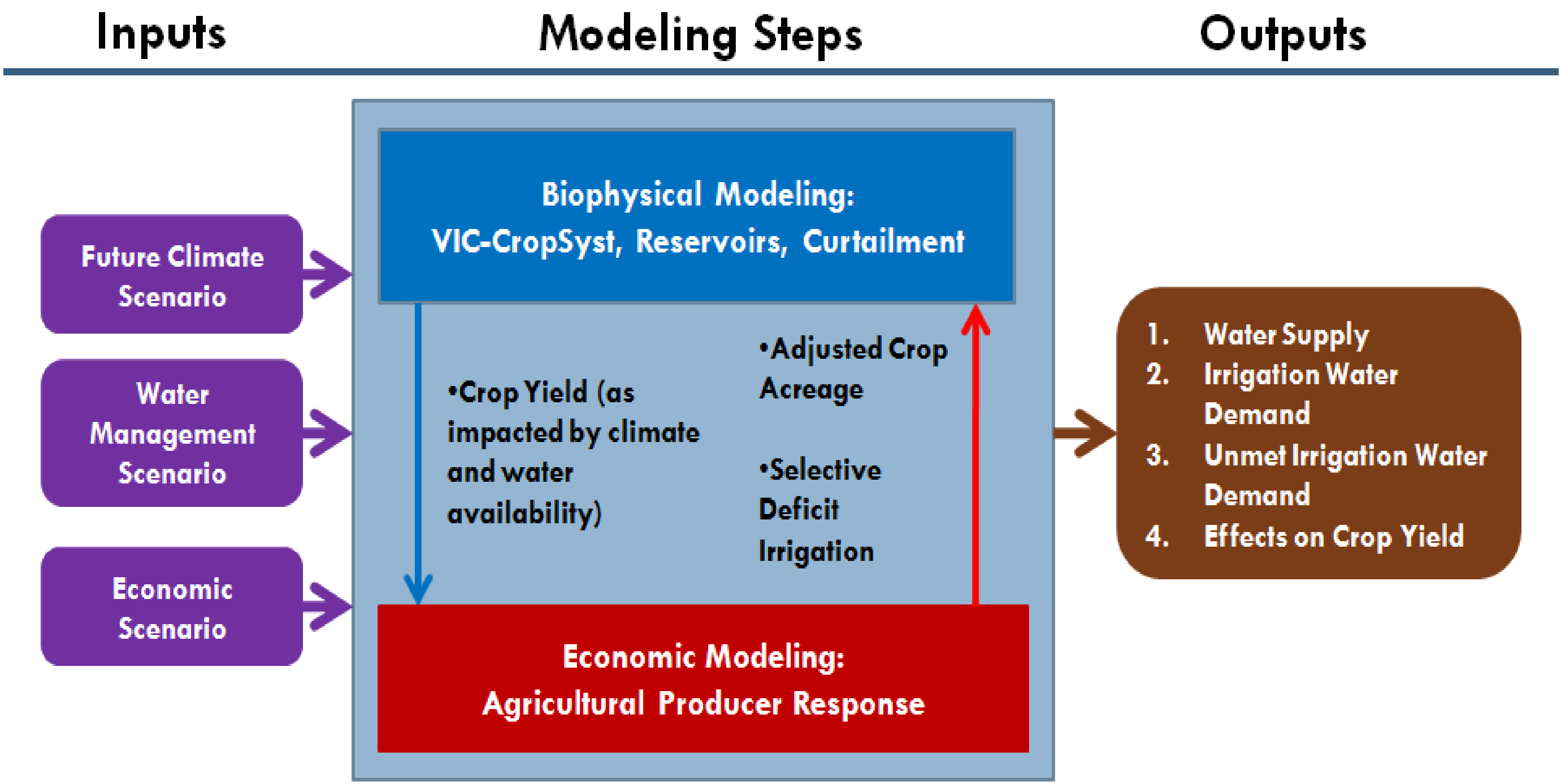


Lateral Drainage



Tague and Band, *Earth Interactions,* 2004
http://fiesta.bren.ucsb.edu/~rhessys

Integrating Economic Models



Example Research Questions:

Nitrogen Dynamics Under Climate Change

Q1. How can economic and policy factors driving N management decisions in cropping systems be modeled?

Q2. How do long-term grassland management schemes, such as grazing and cutting affect productivity, stores of C and N in soils and plants?

Q3. What are the effects of N deposition on high elevation lakes?

Q4. What is the relationship between climate variability and N wet deposition rates in the continental US?

Q5. What is the source contributions of N deposition? What is the impact of fire emissions on N deposition?

Q6. What is the projected change in N deposition rate in 2050s in the PNW due to climate change?

C & N Cycle in Rangeland Systems

Management
- Grazing intensity
- Grazing methods
  - Temporal
  - Spatial

Human N cycle

Agro-ecosystem feedbacks
- Forage quality & quantity

Changes in climate
- Increased CO_2
- Precipitation and temperature shifts

Grassland N

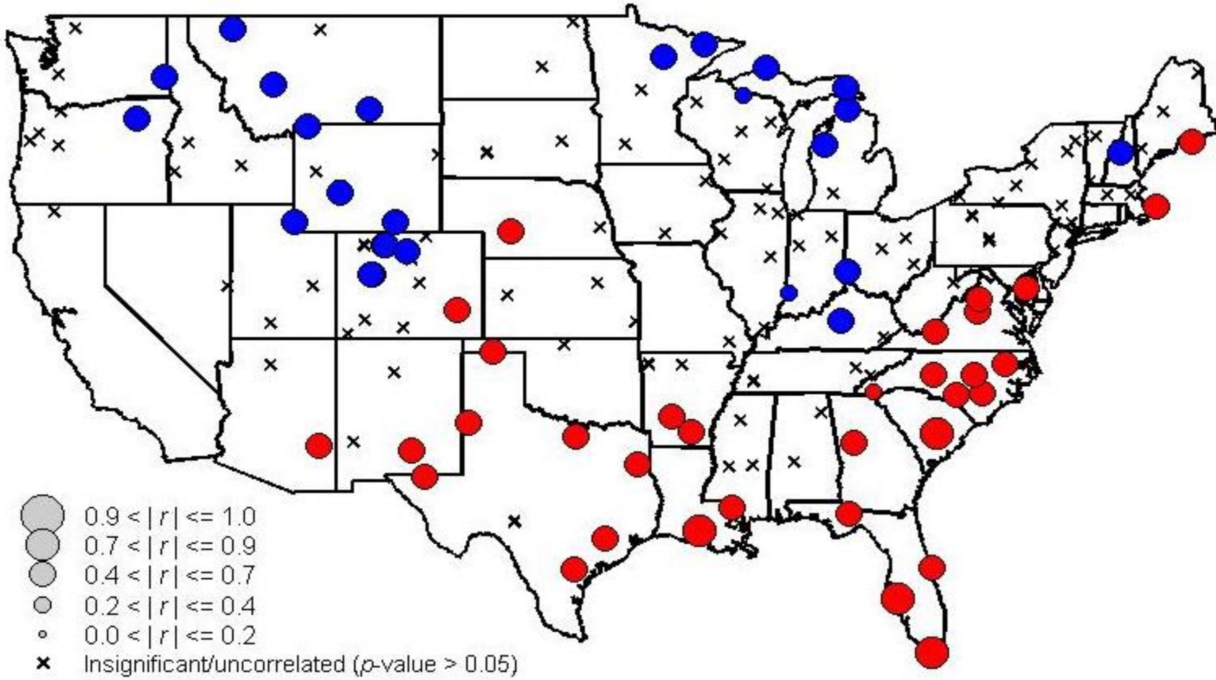
Environmental impact
- N emission
- Methane emission

Soil organic matter (SOM)

C storage

Soil structure

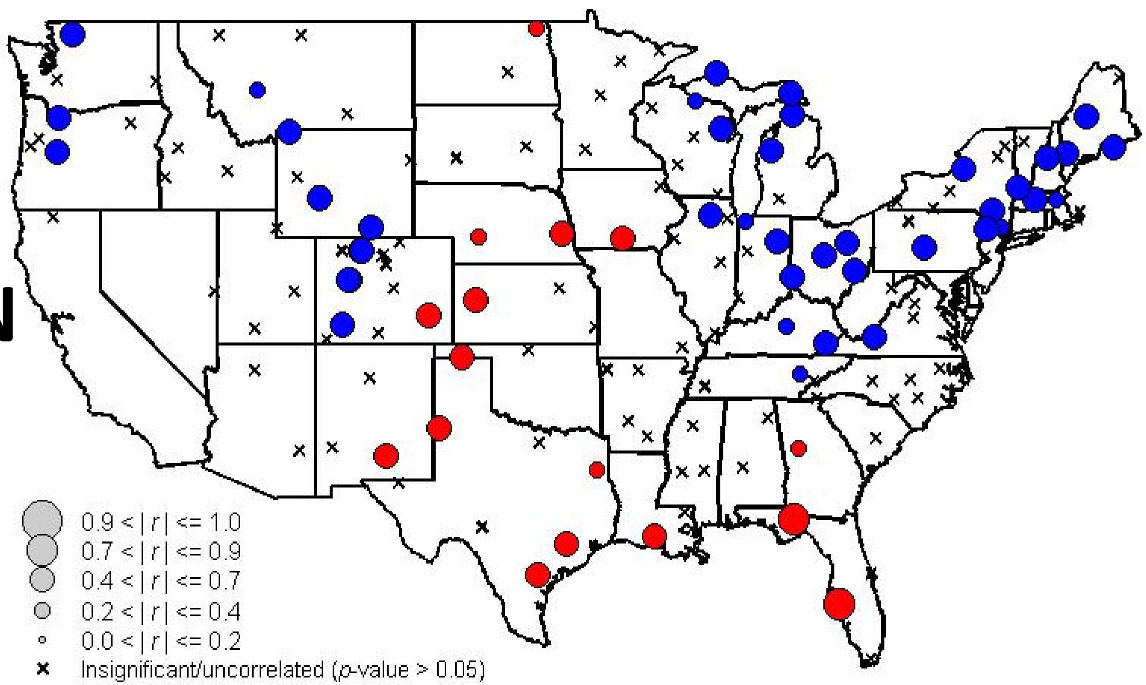
ENSO activity correlation with Precipitation



Blue indicates a positive correlation

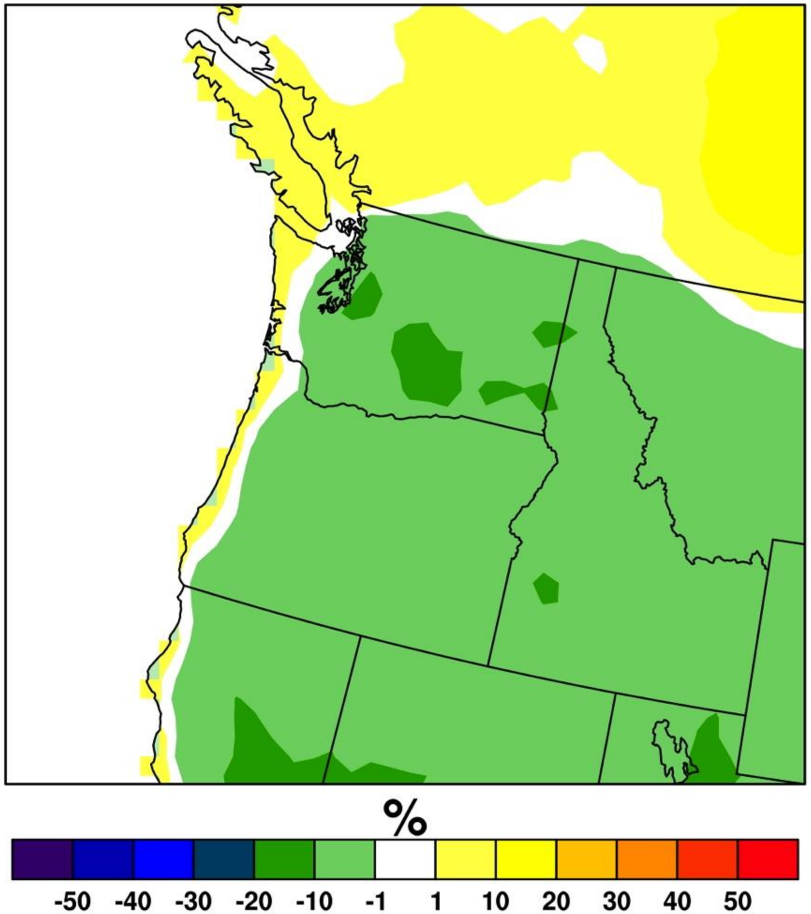
Red indicates a negative correlation

ENSO activity correlation with N wet deposition

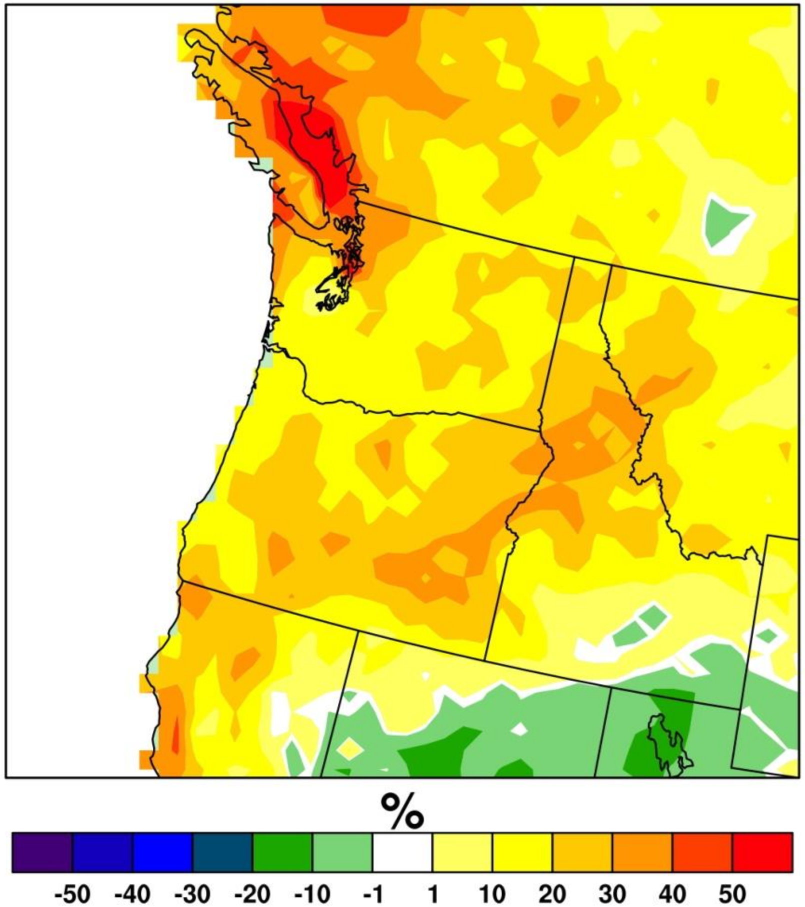


Projected changes in summer season N deposition

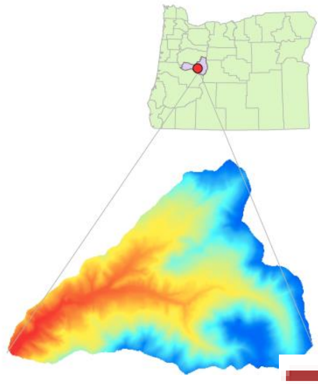
% Change
Due to US Emission Reduction
(2050s, MARKAL)

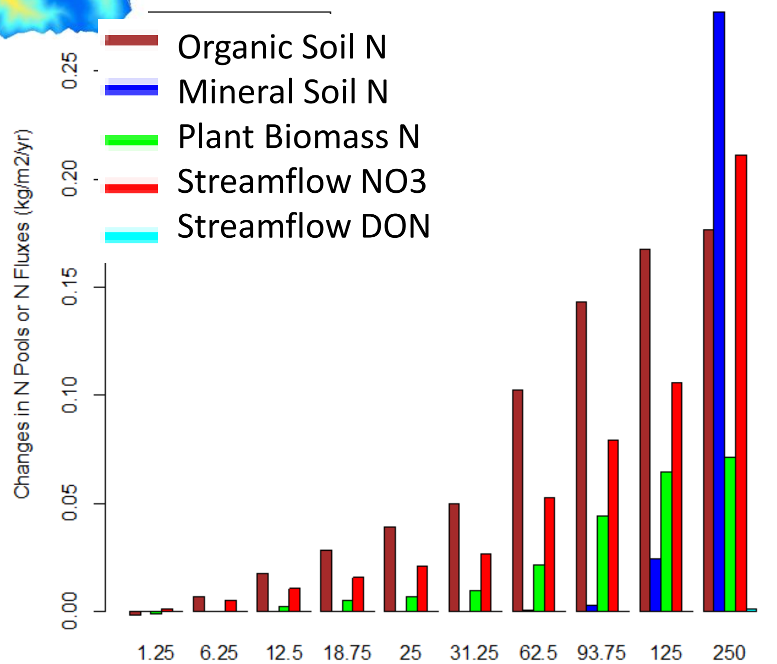


% Change
Due to Climate Change
(2050s, A1B)

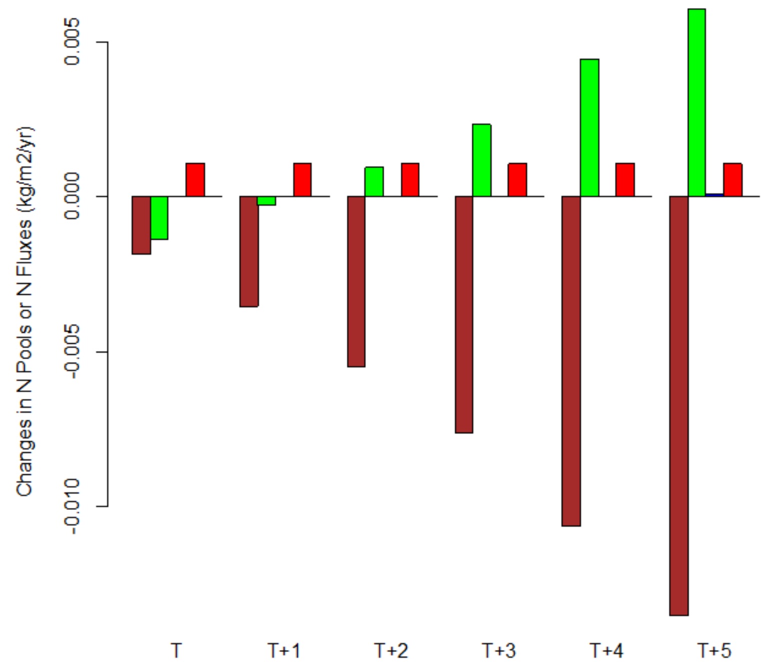


Sensitivity of N-Retention and Export to Temperature and Nitrogen Deposition at the HJ Andrews Experimental Site (Coniferous Forest)





Changes in N stores and fluxes with increasing N deposition



Changes in N stores and fluxes with increasing temperature

For both temperature and N-deposition increase scenarios, responses are relatively linear and the thresholds, where ecosystem behavior shows dramatic changes in the pattern of response, are not likely to be reached within the next decades.

Zhu et al. (in prep)

Stakeholder Engagement Process

Improve our understanding of:

- Drivers of resource management decisions
- Information needs of decision makers (for example, possible climate scenarios or effects of alternative regulatory mechanisms).

Workshop participants: Research Scientists, Industry Representatives, Government Agencies, Environmental Organizations, Non-governmental Organizations

2013

Nitrogen Management

Water Supply

2014

Forest & Rangeland

Water Quality

Air Quality

2015 & Beyond

Water Quality

Continuing communication of model outputs, model refinement based on stakeholder input

To Learn More:

Publications and Workshop Reports available:
http://bioearth.wsu.edu/

Scientific information about regional agriculture:
https://www.agclimate.net/

Water Quality Stakeholder Advisory Workshop MARCH 12 AT WSU VANCOUVER

Contact graduate research assistant Liz Allen, lizb.allen@wsu.edu for registration and information about upcoming workshops

Acknowledgements

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WASHINGTON STATE UNIVERSITY